

Research article

[urn:lsid:zoobank.org/pub:373F006E-1A73-4DDF-A351-E31B41F8A8E0](http://urn.lsid:zoobank.org/pub:373F006E-1A73-4DDF-A351-E31B41F8A8E0)

**New collections of freshwater crabs from northern Madagascar,
with the description of a new species of *Foza* Reed &
Cumberlidge, 2006 (Brachyura, Potamonautidae),
and comments on their conservation status**

Neil CUMBERLIDGE^{1,5}, Sebastian KLAUS^{2,3,6},
Kirstin S. MEYER^{4,7} & Jennifer C. KOPPIN^{1,8}

¹Department of Biology, Northern Michigan University, Marquette, Michigan 49855-5301, U.S.A.

⁵Email: ncumberl@nmu.edu

²Dept. of Ecology and Evolution, J.W. Goethe-University, Max-von-Laue-Str. 13,
D-60438 Frankfurt am Main, Germany. Email: klaus@bio.uni-frankfurt.de

³Chengdu Institute of Biology, Chinese Academy of Sciences, No. 9 Section 4, Renmin
Nan Road, Chengdu, 610041 Sichuan, P.R. China

⁴Oregon Institute of Marine Biology, 63466 Boat Basin Rd, Charleston,
Oregon 97420 USA. Email: kimeyer@alumni.nmu.edu

⁵[urn:lsid:zoobank.org/author:05F6365E-D168-4AE3-B511-80FA7E31ACC1](http://urn.lsid:zoobank.org/author:05F6365E-D168-4AE3-B511-80FA7E31ACC1)

⁶[urn:lsid:zoobank.org/author:94EDE055-0B67-4986-8905-EF51B0398239](http://urn.lsid:zoobank.org/author:94EDE055-0B67-4986-8905-EF51B0398239)

⁷[urn:lsid:zoobank.org/author:AFE96B64-F661-44C4-BE21-11BCFAFF8192](http://urn.lsid:zoobank.org/author:AFE96B64-F661-44C4-BE21-11BCFAFF8192)

⁸[urn:lsid:zoobank.org/author:B2F0EEB4-4F33-47BA-876E-27D384F95432](http://urn.lsid:zoobank.org/author:B2F0EEB4-4F33-47BA-876E-27D384F95432)

Abstract. We report here on recent collections of freshwater crabs from Antsiranana Province, northern Madagascar. The specimens belong to three species, one of which is new to science and is described here. This raises the number of species of freshwater crabs found in Madagascar to 17. All are endemic to the island and all belong to the Afrotropical family Potamonautidae Bott, 1970. The new species, *Foza manonae* sp. nov., is compared to the other species in this genus, and an updated key is provided. It is distinguished from the other three congeners by characters of the male first gonopod, sternum, carapace, and cheliped. The conservation status of the Malagasy freshwater crab fauna is summarized and discussed in light of the new material reported on here belonging to two other species, *Madagapotamon humberti* Bott, 1965 and *Foza ambohitra* Cumberlidge & Meyer, 2009.

Key words. Crustacea, taxonomy, *Foza*, new species, Madagascar, conservation

Cumberlidge N., Klaus S., Meyer K.S. & Koppin J.C. 2015. New collections of freshwater crabs from northern Madagascar, with the description of a new species of *Foza* Reed & Cumberlidge, 2006 (Brachyura, Potamonautidae), and comments on their conservation status. *European Journal of Taxonomy* 109: 1–15. <http://dx.doi.org/10.5852/ejt.2015.109>

Introduction

Freshwater crabs are found throughout Madagascar in forested, savanna, and highland habitats, and are particularly species rich in the northern parts of the island where several biodiversity hotspots have been identified (Cumberlidge *et al.* 2004). These crabs live in lakes, streams, and rivers, as well as in adjacent terrestrial habitats that include rocky crevices and phytotelmata (Cumberlidge *et al.* 2002, 2005). All freshwater crabs found in Madagascar are included in the Afrotropical family Potamonautidae Bott, 1970 (Bott 1960, 1965; Ng & Takeda 1994; Cumberlidge 1999, 2014; Cumberlidge *et al.* 2002, 2007; Cumberlidge & Sternberg 2002; Reed & Cumberlidge 2006; Cumberlidge & Meyer 2009; Meyer *et al.* 2014). The high degree of endemism shown by the Malagasy freshwater crabs (100% at the genus and species levels) is a characteristic that they share with many other freshwater organisms from this long-isolated tropical island.

We report here on recent collections of freshwater crabs from Antsiranana Province, northern Madagascar. The specimens belong to two genera: *Foza* Reed & Cumberlidge, 2006 (that currently includes three species) and *Madagapotamon* Bott, 1965, a monotypic genus. *Foza* was established with the description of *F. raimundi* Cumberlidge & Reed, 2006, the type species, from Marojejy in northern Madagascar and expanded in 2009 by the inclusion of two other species, *F. ambohitra* Cumberlidge & Meyer, 2009 and *F. goudoti* (H. Milne Edwards, 1853). The fourth species of this genus, *Foza manonae* sp. nov., described here, is recognized by a combination of morphological characters including those of the mandible, gonopods, carapace, sternum, and cheliped (Table 1).

The new species is described, figured, and compared with other species in this genus, and an updated key to the genus is provided. In addition, the conservation status of the Malagasy freshwater crab fauna is discussed for the 14 species known at the time of the last IUCN Red List assessment (Cumberlidge *et al.* 2009). Of these, two species (*Boreathelphusa uglovi* (Cumberlidge & Sternberg, 2002) and *Madagapotamon humberti* Bott, 1965) are currently listed as ‘vulnerable to extinction’, and five other species are too poorly known to even assess their conservation status (Table 2).

Material and methods

All measurements were made with digital calipers and are given in mm. The terminology is adapted from Cumberlidge (1999) and Cumberlidge & Sternberg (2002). Line drawings were prepared using a Leica MZ 16 stereobinocular microscope. The habitus photographs were taken with a Panasonic Lumix digital camera. Post processing was done in Adobe Photoshop 7.0. Specimens examined are deposited in the Zoologische Staatssammlung München (the Bavarian State Collection of Zoology, ZSM).

The following abbreviations are used in this paper:

a	=	abdominal somite
a7/a6	=	sutures between abdominal somites
CH	=	carapace height measured at maximum height of cephalothorax (mm)
CL	=	carapace length measured along median line from anterior to posterior margin (mm)
CW	=	carapace width measured at widest point (mm)
e	=	thoracic episternite
FW	=	front width measured along anterior frontal margin between orbits (mm)
G1	=	first gonopod
G2	=	second gonopod
IUCN	=	International Union for the Conservation of Nature
MNHN	=	Muséum national d’Histoire naturelle, Paris
p1–p5	=	pereiopods 1–5

s	=	thoracic sternite
s4/s5	=	sternal sulci between adjacent thoracic sternites
s4/e4	=	episternal sulci between adjacent thoracic sternites and episternites
SMF	=	Senckenberg Museum, Frankfurt, Germany
ZSM	=	Zoologische Staatssammlung München, Germany

Results

Infraorder Brachyura Latreille, 1802
Superfamily Potamoidea Ortmann, 1896
Family Potamonautidae Bott, 1970
Subfamily Deckeniinae Ortmann, 1897
Foza Reed & Cumberlidge, 2006

Foza manonae sp. nov.

urn:lsid:zoobank.org:act:B73D6977-4FF3-4C7A-A2ED-8CED73466A54

Figs 1–3, Table 1

Diagnosis

Mid-proximal portion of G1 terminal article widened laterally by rounded lobe; s3/s4 incomplete, faint in middle deep at sides; anterolateral and posterolateral surfaces of carapace with conspicuous carinae; subhepatic region of carapace sidewall with carinae; anterior pterygostomial region of carapace sidewall heavily granulated.

Etymology

The new species is named for the first author's late wife, Dr. Louise Manon Bourgault, in recognition of her numerous contributions to freshwater crab biology during her time spent researching communication in Africa and Madagascar.

Material examined

Holotype

MADAGASCAR: Adult ♂, Antsiranana Province, Ankarana Special Reserve, 12.92° S, 49.14° E, near pitfall trap site, coll. F. Glaw, M. Franzen, J. Köhler & N. d'Cruze, 13 Feb. 2008 (CW 43.7, CL 32.6, CH 18.7, FW 10.5) (ZSM A20145003).

Paratype

MADAGASCAR: Adult ♀, Antsiranana Province, same locality (CW 42.4, CL 32.2, CH 18.3, FW 10.4) (ZSM A20145004).

Other material examined

MADAGASCAR: Sub-adult ♀, Antsiranana Province, Montagne des Français Reserve, 12.34° S, 49.35° E, in pitfall trap, coll. N. d'Cruze *et al.*, 19 Feb. 2008 (CW 36.9, CL 29.0, CH 15.8, FW 9.0) (ZSM A20145005); juvenile, same locality (CW 12.1, CL 10.4, CH 5.8, FW 4.6) (ZSM A20145006).

Description

Based on holotype (adult ♂, CW 43.7). Carapace outline transversely oval, high (CH/FW 1.75); front narrow (FW/CW 0.28), deflexed; epibranchial tooth small, pointed, extremely advanced in position; anterolateral margin evenly curved outward, lined by small granules; postfrontal crest faint, incomplete postorbital crests, epigastric crests well defined, positioned forward on front; deep wide mid-groove between epigastric crests; cardiac urogastric grooves deep, cervical grooves deep posteriorly, faint

anteriorly, long, almost reaching postfrontal crest. Anterolateral and posterolateral surfaces of carapace with conspicuous carinae. Suborbital region of carapace sidewall with small granules, subhepatic region with carinae, pterygostomial region heavily granulated with setae in inferior part; vertical sulcus on carapace sidewall curved, granular, running from base of epibranchial tooth to epimeral sulcus. Epistomial tooth triangular, deflexed, edges smooth. Exopod of third maxilliped long, reaching ischium/merus junction, flagellum of exopod long, ischium with deep vertical groove. Mandibular palp 2-segmented

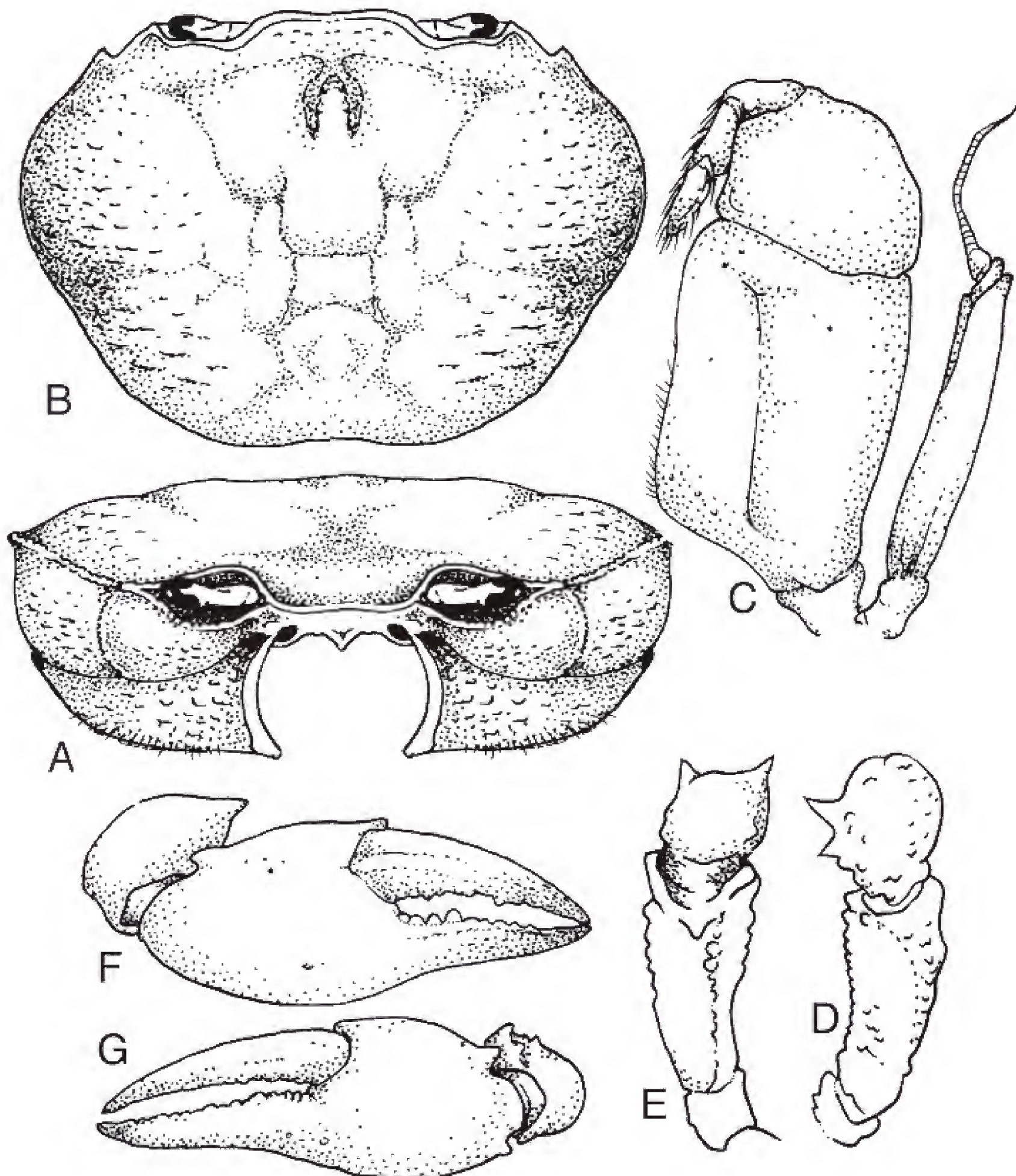


Fig. 1. *Foza manonae* sp. nov. Holotype, adult ♂, CW 43.7 mm, Ankarana Special Reserve, Madagascar (ZSM A20145003). A. Carapace, frontal view. B. Carapace, dorsal view. C. Third maxilliped, ventral view. D. Carpus and merus of cheliped, dorsal view. E. Carpus and merus of cheliped, ventral view. F. Right cheliped, frontal view. G. Left cheliped, frontal view.

with small, hard, rounded lobe at junction between segments, lobe one-third length of terminal segment. s1/s2 short, very faint; s2/s3 deep, wide, completely crossing sternum; s3/s4 incomplete, faint in middle deep at sides. Episternal sulci s4/e4, s5/e5, s6/e6, s7/e7 absent. Male abdomen triangular, tapered, widest at a3, narrowest at a7 (telson); telson outline forming straight-sided triangle with broad base, rounded

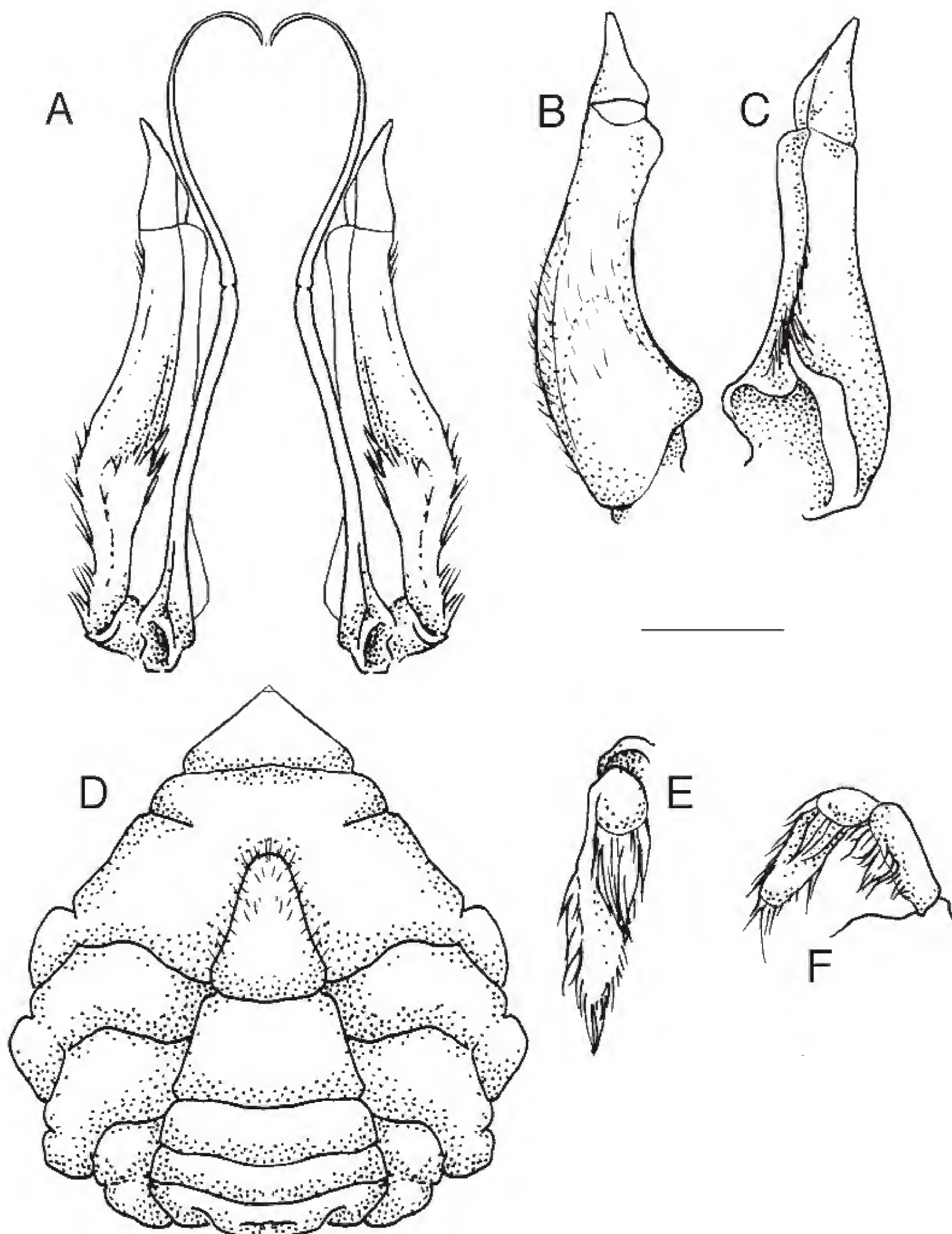


Fig. 2. *Foza manonae* sp. nov. Holotype, adult ♂, CW 43.7 mm, Ankarana Special Reserve, Madagascar (ZSMA20145003). **A.** Left and right G1 and G2 shown *in situ* in ventral view. **B.** Left G1, dorsal view. **C.** Left G1, ventral view. **D.** Sternum and abdomen, ventral view. **E.** Left mandibular palp, superior view. **F.** Left mandibular palp, frontal view. Scale bar: 14 mm (A–B, E), 23.2 mm (C–D).

apex. Sternal grooves s4/s5 meeting telson just beyond abdominal groove between a7/a6; sternal grooves s5/s6 meeting a6 one half somite length from a6/a5; sternal grooves s6/s7 meeting a5 one third somite length from a5/a4.

G1 terminal article short (ratio of length of terminal article to subterminal segment 0.27), cone-shaped, straight, tapering to broad tip, apical opening narrow, directed slightly outward, smooth; mid-proximal portion of G1 terminal article widened laterally by rounded lobe; lateral, medial folds basally separated, meeting midway along ventral face, forming longitudinal groove that continues almost to tip of article; groove not visible on dorsal face. Subterminal segment of G1 with raised rounded shoulder on lateral margin near junction with terminal article. Terminal article/subterminal segment junction of G1 marked by faint diagonal line on ventral side, dorsal side marked by broad, subtriangular dorsal membrane; superior margin of dorsal membrane formed by horizontal basal margin of terminal article, inferior margin of membrane formed by U-shaped distal edge of subterminal segment; lateral, medial margins of dorsal membrane narrow. Terminal article of G2 flagellum-like, long, reaching anterior margin of sternoabdominal cavity; flagellae of G2 viewed together *in situ* forming heart shape; distal parts of terminal articles of both G2s touching, sometimes protruding from under closed abdominal telson.

Movable finger (dactylus) of major (right) cheliped slender, upper margin smooth. Fixed finger long, $\frac{1}{3}$ height of palm; lower margin of palm slightly indented; proximal region of cutting edge of fixed finger with four large, fused molars followed distally by series of small teeth. Carpus with two teeth on inner margin, first tooth large, pointed, second tooth smaller, pointed, followed by series of very small teeth. Medial, lateral margins of inferior face of cheliped merus distinctly toothed, inferior face with pointed, granulated, distal tooth; superior margin and superior face of merus covered with granules and short carinae; granules on medial margin of merus continuous with granules on medial margin of cheliped ischium, inferior margin of ischium rounded, smooth. Walking legs (p2–p5) of normal length, not strikingly elongated, inner margins of propodi of p2 to p5 smooth.

Size

The largest known specimen is the male holotype, CW 43.7. Adults judged by size at pubertal molt are between CW 37 and CW 42.

Type locality

Ankarana Special Reserve, 12.92° S, 49.14° E, Antsiranana Province, northern Madagascar.

Distribution

Foza manonae sp. nov. is known only from two localities in Antsiranana Province in northern Madagascar: Ankarana Special Reserve and Montagne des Français Reserve (Fig. 4).

Ecology

At the Ankarana Special Reserve the new species is found in sympatry with two other species of freshwater crabs: *Foza ambohitra* (ZSM A20145001, ZSM A20145002) and *Madagapotamon humberti* (ZSM A20145007, ZSM A20145008, ZSM A20145009, ZSM A20145010). *Foza manonae* sp. nov. is also found in sympatry with *M. humberti* (ZSM A20145012) at Montagne des Français Reserve, where the two species were caught together in pitfall traps. Both *F. ambohitra* and *M. humberti* are known to be semi-terrestrial air-breathing crabs (Cumberlidge & Meyer 2009), so it is likely that *F. manonae* sp. nov. also has similar habits and abilities, and also has a similar degree of independence from permanent water sources. Furthermore, the branchial chambers of *F. manonae* sp. nov. (like those of *F. ambohitra*) each house two different sets of respiratory organs: a dorsal pseudolung for aerial respiration and ventral gills for aquatic respiration (Sternberg & Cumberlidge 2001).

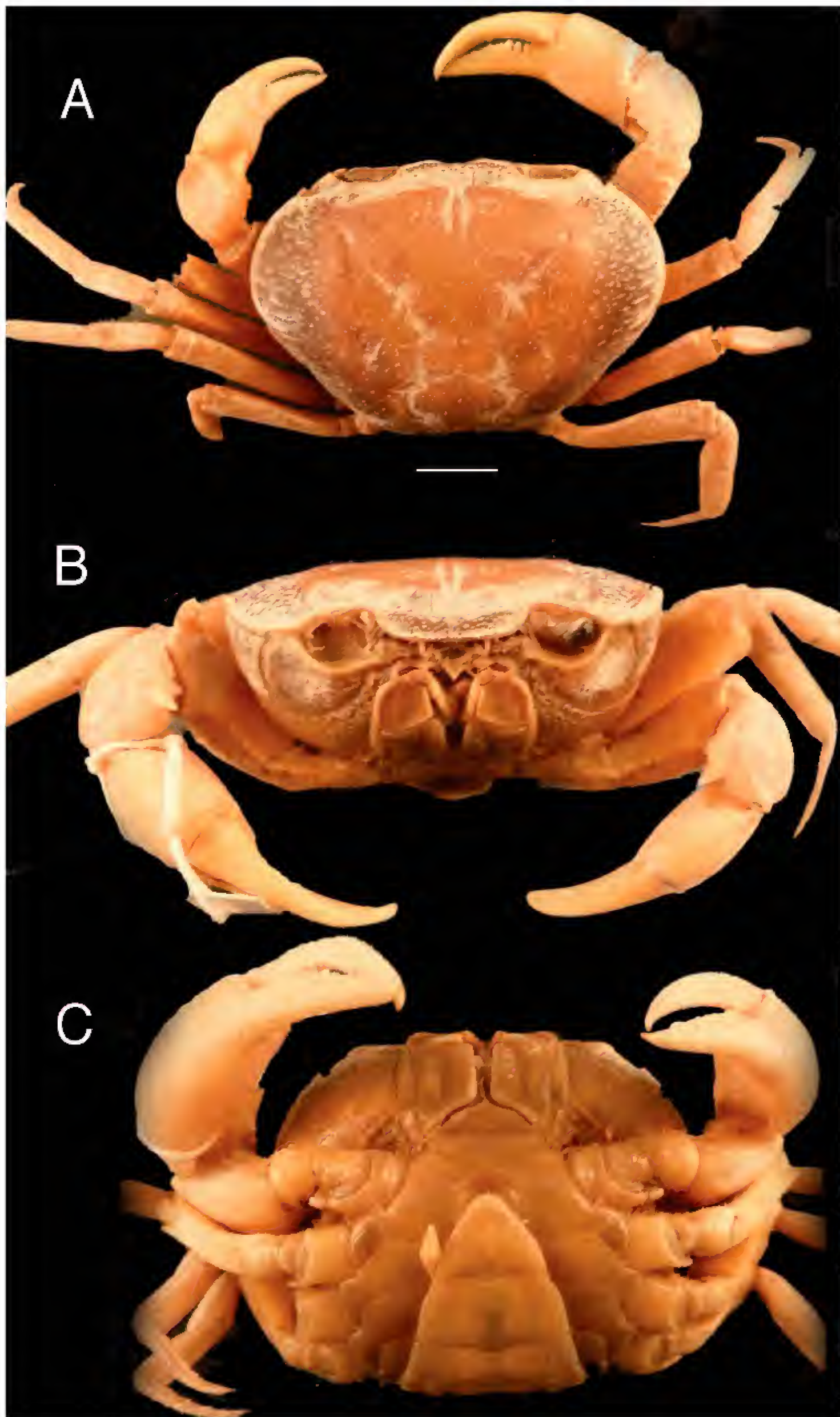


Fig. 3. *Foza manonae* sp. nov. Holotype, adult ♂, CW 43.7 mm, Ankarana Special Reserve, Madagascar (ZSMA20145003). Entire animal. **A.** Dorsal view. **B.** Frontal view. **C.** Sternal view. Scale bar: 14.6 mm.

Remarks

The differences between *Foza* and the other Malagasy freshwater crab genera are discussed by Reed & Cumberlidge (2006), Cumberlidge & Meyer (2009), and Meyer *et al.* (2014). *Foza manonae* sp. nov. is assigned to the genus *Foza* on the basis of characters that it shares with *F. raimundi* Reed & Cumberlidge, 2006, the type species of the genus (Reed & Cumberlidge 2006). These characters include a bilobed mandibular palp, a faint postfrontal crest, sternal grooves s6/s7 that meet the margin of abdominal segment a5 in the middle of the segment, and curved, elongated G2s that together form a distinctive heart shape (Fig. 2A). A preliminary DNA comparison of 16S rRNA sequences of *F. manonae* sp. nov. with those of other Malagasy freshwater crab species available from GenBank was made by the second author (SK, unpublished data). The results positioned the new species in a separate clade, although the taxonomic sampling and exact identity of the species to which the other sequences belong is currently the focus of a larger molecular phylogenetic study of the Malagasy freshwater crab fauna using a wider range of molecular markers (S.R. Daniels, pers. comm.).

The four species of *Foza* are compared in Table 1 and can be identified as follows: *Foza manonae* sp. nov. can be distinguished from *F. raimundi* Reed & Cumberlidge, 2006 by the texture of the anterolateral surfaces of the carapace (which have heavy carinae in *F. manonae* sp. nov. but are smooth, or with only a few light carinae in *F. raimundi*), by the texture of the suborbital and subhepatic regions of the carapace sidewall (which have granules and/or carinae in *F. manonae* sp. nov. but are smooth in *F. raimundi*), by the terminal article of G1 (which is cone-shaped in *F. manonae* sp. nov. and tube-shaped in *F. raimundi*),

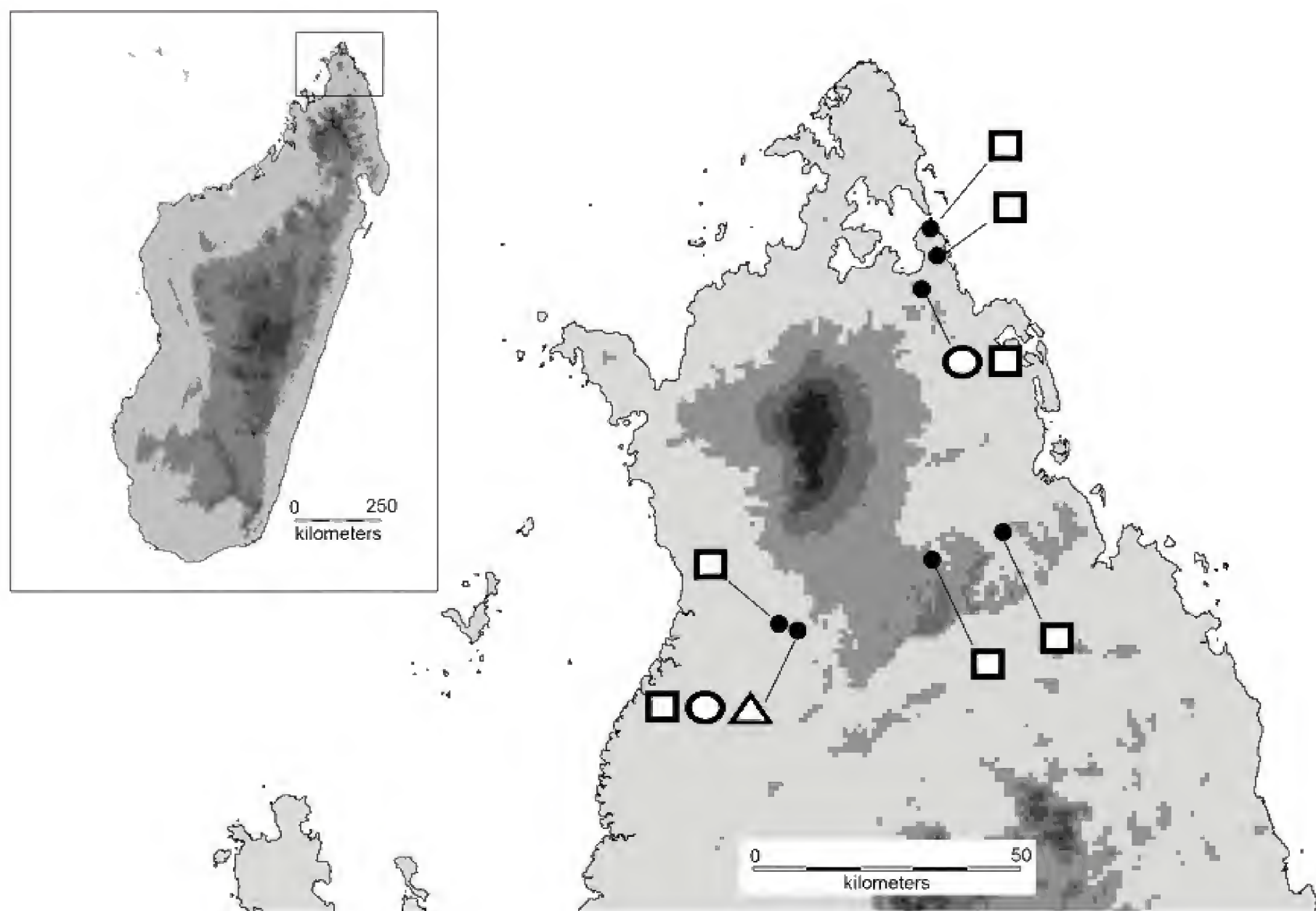


Fig. 4. Distribution map of northern Madagascar showing the seven localities (black circles) where freshwater crabs were collected in the present study: *Foza manonae* sp. nov. (white circles), *F. ambohitra* (triangle), and *Madagapotamon humberti* (squares).

Table 1. Comparison of the morphological characters of the species in the genus *Foza*.

Character	<i>F. raimundi</i>	<i>F. goudoti</i>	<i>F. ambohitra</i>	<i>F. manonae</i> sp. nov.
Postfrontal crest	faint	distinct	faint	faint
Anterolateral surface of carapace	smooth, light carapace	smooth	smooth, light carapace	heavy carinae
Postlateral surface of carapace	light carinae	light carinae	smooth	heavy carinae
Cervical grooves	short	long	long	long
Suborbital region	smooth	large granules	smooth	small granules
Subhepatic region	smooth	smooth	smooth	carinae
Anterior pterygostomial region	dense setae all over	inferior region with setae	inferior region with setae	inferior region with setae
Anterior pterygostomial region	smooth	superior region with granules	superior region with granules	heavily granulated all over
G1 terminal article	tube-shaped, not widened	cone-shaped, not widened	cone-shaped, not widened	cone-shaped, laterally widened by raised lobe
G2 terminal segment	left one shaped like question mark, together form heart shape	straight, long, no distal curve	left one shaped like question mark, together form heart shape	left one shaped like question mark, together form heart shape
Sternoabdominal cavity	dense setae	no/few setae	no/few setae	no/few setae
s3/s4	complete, u-shaped	complete, v-shaped	complete, u-shaped	shallow in middle, deep at sides
s6/s7 meets a5	at middle margins of somite	at a5/a6 junction	at a5/a6 junction	at middle margins of somite
Major cheliped proximal propodus	one molar	3–4 molars	3–4 molars	3–4 molars

by the pterygostomial region and the sternoabdominal cavity (which largely lack setae in *F. manonae* sp. nov. but have dense fields of setae in *F. raimundi*), and by the sternal sulcus s3/s4 (which is incomplete and only visible at the sides in *F. manonae* sp. nov., but complete and crossing the entire thoracic sternum in *F. raimundi*).

Foza manonae sp. nov. can be distinguished from *F. ambohitra* by the texture of the posterolateral corners of the carapace (which have heavy carinae in *F. manonae* sp. nov., but are smooth with a few light carinae in *F. ambohitra*), by the texture of the suborbital and subhepatic regions of the carapace sidewall (which have granules and/or carinae in *F. manonae* sp. nov., but are smooth in *F. ambohitra*), by the suborbital and subhepatic regions of the carapace sidewall (which are granulated in *F. manonae* sp. nov., but smooth in *F. ambohitra*), and by the terminal article of G1 (which is widened in *F. manonae* sp. nov., but slim and evenly tapered in *F. ambohitra*).

Foza manonae sp. nov. can be distinguished from *F. goudoti* by the postfrontal crest (which is faint and incomplete in *F. manonae* sp. nov., but distinct and completely crosses the carapace in *F. goudoti*), by the anterolateral surfaces of the carapace (which have heavy carinae in *F. manonae* sp. nov., but are

smooth or with only a few light carinae in *F. goudoti*), by the subhepatic region of the carapace sidewall (which has carinae in *F. manonae* sp. nov., but is smooth in *F. goudoti*), and by the terminal articles of G2 (which are curved distally, forming a distinctive heart shape in *F. manonae* sp. nov., but are slim, long, and straight in *F. goudoti*).

Foza ambohitra Cumberlidge & Meyer, 2009

Material examined

MADAGASCAR: 2 adult ♂♂, Antsiranana Province, Ankarana Special Reserve, 12.92° S, 49.14° E, coll. F. Glaw, M. Franzen, J. Köhler & N. d’Cruze, 13 Feb. 2008 (CW 50, CI 31.6; CW 43, CL 30) (ZSM A20145001, ZSM A20145002).

Distribution

This species was described by Cumberlidge & Meyer (2009) from specimens collected in Antsiranana Province, northern Madagascar, at Ambohitra (formerly Joffreville) in the Diana Region, and at two localities in the Analamerana Special Reserve. The present report adds a new locality for this species: the Ankarana Special Reserve (Fig. 4). In light of the new material and preliminary DNA analysis, it is possible that the specimen from Toamasina Province, Montagne d’Akirindro (NMU PN 17–21.3.2003), included in *F. ambohitra* by Cumberlidge & Meyer (2009), may not prove to belong to this species (S.R. Daniels, pers. comm.).

Remarks

Foza ambohitra is a medium-sized species that lives in the mixed dry deciduous and humid forests of northern Madagascar. The species can be recognized by its anterolateral margins (granular), its carapace sidewalls (completely smooth except for a small field of granules at the junction of the longitudinal and vertical sutures), and by its sternal sulcus s3/s4 (which is complete, U-shaped, and does not meet the sternoabdominal cavity).

The material reported on here also includes two small juvenile crabs (CW 9.5, CL 7.6 and CW 9.0, CL 7.2) (ZSM A20145014) from the Ankarana Special Reserve that are difficult to identify because their morphology includes a number of characters that have yet to develop to the adult form. Nevertheless, these specimens clearly belong to the genus *Foza* and were collected at the same locality as the specimens of *F. ambohitra* (ZSM A20145001, ZSM A20145002). However, we hesitate to assign these juvenile specimens to *F. ambohitra* because they possess dense fields of setae on the anterior pterygostomial region of the carapace sidewall, and because they have very elongated walking legs, both of which are characters that would place them close to *F. raimundi*.

Key to the species of *Foza*

1. G1 terminal article widened by raised lobe; s3/s4 incomplete, faint in middle, deep at sides; subhepatic region of carapace sidewall with carinae*F. manonae* sp. nov.
– G1 terminal article slim, not widened; s3/s4 deep, completely crossing thoracic sternum; subhepatic region of carapace sidewall smooth2
2. Dense setae in pterygostomial region and in sternoabdominal cavity; cervical grooves short; proximal region of fixed finger of major cheliped with single large molar; s6/s7 meeting margins of a5 in middle of somite*F. raimundi* Reed & Cumberlidge, 2006
– Dense setae lacking in pterygostomial region and in sternoabdominal cavity; cervical grooves long; proximal region of fixed finger of propodus of major cheliped with 3–4 large molars; s6/s7 meeting margins of a5 at a5/a6 junction3

3. G2 terminal articles straight, long, not hooked over at tips; suborbital region of carapace sidewall with large granules; postfrontal crest complete, distinct*F. goudoti* (H. Milne Edwards, 1853)
 – G2 terminal articles distinctly curved distally, together forming distinctive heart-shape; suborbital region of carapace sidewall smooth; postfrontal crest faint, incomplete
*F. ambohitra* Cumberlidge & Meyer, 2009

Madagapotamon humberti Bott, 1965

Madagapotamon humberti Bott, 1965: 344–346, fig. 7, pl. 4, figs 14–17. — Vuillemin 1970: 245–265. — Ng & Takeda 1994: 162–163, table 1. — Cumberlidge & Sternberg 2002: figs 2e, 3g, 4l, 5h, 6g, 7k–l, 8g, 10g–h, 11h. — Ng, Guinot & Davie 2008: 165.

Material examined

MADAGASCAR: All from Antsiranana Province. – Ankarana Special Reserve, 12.92° S, 49.14° E, in pitfall trap, all coll. F. Glaw, M. Franzen, J. Köhler & N. d’Cruze, 12 Feb. 2008: damaged, CW 21.5 (ZSM A20145007); damaged, CW 34.6 (ZSM A20145008); damaged, legs only (ZSM A20145009); damaged, CW 18.2 (ZSM A20145010). – Ankarana Special Reserve, Encampment des Anglais (Anilotra), 7.5 km NW of Mahamajina, 12.91° S, 49.11° E, mostly undisturbed tsingy forest, on cliff face, 125 m asl, coll. S.M. Goodman, 8 Apr. 2002, 1 specimen (FMNH 7577). – Baie de Sakalava, Köhler-Stelle, 12.28° S, 49.38° E, coll. F. Glaw, M. Franzen, J. Köhler & N. d’Cruze, 17 Feb. 2008, 2 adult ♀♀ (CW 34.3, CL 28.9, CH 13.1, FW 6.6; CW 28.9, CL 21.0) + 2 juvenile ♂♂ (CW 21.1; CW 19.8) (ZSM A20145011). – Passe d’Orangea Reserve, 12.23° S, 49.37° E, pitfall, coll. S. Megson, 22 Feb. 2008, subadult ♂ (CW 28.8, CL 21.9); damaged subadult ♀ (CW 31.6, CL 21.5); damaged specimen (ZSM A20145013). – Montagne des Français Reserve, 12.34° S, 49.35° E, in pitfall trap, coll. N. d’Cruze *et al.*, 19 Feb. 2008, 1 specimen, damaged (ZSM A20145012). – Analamerana Special Reserve, 8.6 km SE of Menagisy, Forêt d’Analabe, along Bobakindro River, 12.80° S, 49.37° E, partially disturbed dry deciduous forest, on ground during day near pitfall trap number 2, 40 m asl, all coll. S.M. Goodman, 17–21 Jan. 2004: 1 specimen (FMNH 11033); adult ♂ (CW 38.6) + adult ♀ (CW 32.6) (FMNH 11034); 1 specimen (FMNH 11035); adult ♂ (CW 35.4) + adult ♀ (CW 27.6) (FMNH 11036); adult ♀ (CW 33) (FMNH 11037). – Analamerana Special Reserve, 8.6 km SE of Menagisy, Forêt d’Analabe, along Bobakindro River, 12.75° S, 49.49° E, partially disturbed dry deciduous forest, found climbing up a tree during middle afternoon, 40 m asl, coll. S.M. Goodman, 18 Jan. 2004, 1 specimen (FMNH 11035). – Analamerana Special Reserve, Forêt d’Ankavanana, 15.8 km SE of Anivorano-Nord, 12.8° S, 49.37° E, partially disturbed mixed dry deciduous and humid forest, found during early morning check, 200 m asl, all coll. S.M. Goodman, 23–27 Jan. 2004: adult ♂ (CW 29.6) (FMNH 11044a); adult ♂ (CW 44.3) (FMNH 11047); 1 specimen (FMNH 11048); 1 specimen (FMNH 11053); adult ♂ (CW 42.7) (FMNH 11055); subadult ♀ (CW 29.1) (FMNH 11057).

Distribution

This species was described by Bott (1965) from specimens collected in dry deciduous forests in the Ankarana Special Reserve in Antsiranana Province in northern Madagascar. The present work adds further material from this locality, plus several more specimens from two other localities in the Analamerana Special Reserve in Antsiranana Province (Fig. 4). We are also able to confirm the continued presence of *M. humberti* in Montagne des Français Special Reserve near the coastal city of Antsiranana (formerly Diego-Suarez), adding to the previous record which was based on specimens collected in 1899 (MNHN-B 5034) (Cumberlidge & Sternberg 2002). This species has also been reported to occur on the island of Nosy Be in Antsiranana Province (ZSM 1163/1; SMF 4487) (Cumberlidge & Sternberg 2002). Two new localities for *M. humberti* are reported here: Baie de Sakalava (Köhler-Stelle, inland locality) and the Passe de Orangea Reserve, both of which are relatively close to the city of Antsiranana in Antsiranana Province.

Remarks

Madagapotamon humberti is one of the most distinctive species of all of the Madagascan freshwater crabs and this colorful, long-legged, rock-crevice and cave-dwelling species stands apart from all others on the island. *M. humberti* can easily be distinguished by the absence of a flagellum on the exopod of the third maxilliped, by the mandibular palp with a simple terminal segment, and by the egg-shaped outline of the adult male abdomen. Living specimens from the Ankarana Special Reserve have a yellow carapace, pink legs, and chelipeds with white fingers, while those from Montagne des Français Reserve have an all-white carapace, along with pink legs and chelipeds with white fingers.

Discussion

Conservation status of Malagasy freshwater crabs

Table 2 provides a list of the 17 species of Malagasy freshwater crabs (in eight genera), with the conservation status of the 14 species that were assessed using the IUCN Red List protocols by Cumberlidge *et al.* (2009). One half of the Malagasy freshwater crab fauna (seven out of 14 species) were assessed as Least Concern (LC), including two species of *Foza*, four species of *Hydrothelphusa* A. Milne-Edwards, 1872 and one species of *Malagasya* Cumberlidge & Sternberg, 2002 (Table 2). Two species (*Boreathelphusa uglowi* (Cumberlidge & Sternberg, 2002) and *Madagapotamon humberti* Bott, 1965) were found to be vulnerable to extinction (VU) and another five (*Malagasya goodmani* Cumberlidge, Boyko & Harvey, 2002; *Marojejy longimerus* (Cumberlidge, Boyko & Harvey, 2002); *Skelosophusa gollhardi* (Bott, 1965); *S. proluxa* Ng & Takeda, 1994; *S. eumeces* Ng & Takeda, 1994) were Data Deficient (DD) – i.e., they were too poorly known to even carry out a conservation assessment (Cumberlidge 2008a, 2008b).

The five Malagasy DD species of freshwater crabs (35% of the fauna) introduce an element of uncertainty into the conservation planning process because their conservation status (when assessed) may either increase or decrease the number of threatened species (VU, EN, or CR), or it may not change current estimates if all of these species prove to be LC. However, it is likely that most of the DD species will be assessed as belonging to a threatened category because many of the DD species are single-locality endemics with a very narrow distributional range, a profile typical of many of the species currently in threatened categories worldwide (Cumberlidge *et al.* 2009). For example, Sri Lanka is one of the few countries where the conservation status of the entire freshwater crab fauna has been assessed, and its faunal list therefore includes no DD species (Bahir *et al.* 2005; Cumberlidge *et al.* 2009). These studies show that Sri Lanka has the highest number of threatened species of freshwater crabs of any country in the world and that many of these species are single-locality endemics (Cumberlidge *et al.* 2009). Clearly, the VU and DD species of endemic Madagascan freshwater crabs present obvious foci for future ecological fieldwork, biotic inventories, and conservation prioritization activities.

The specimens reported on here (Fig. 4) were collected within a number of protected areas in the generally dry Antsiranana Province, all of which feature deciduous dry forest and limestone massifs with karst formations (tsingy). These protected areas are Ankarana Special Reserve (*F. manonae* sp. nov., *F. ambohitra*, and *M. humberti*), Montagne des Français Reserve (*F. manonae* sp. nov. and *M. humberti*), the Orangea Reserve (*M. humberti*), and Analamerana Special Reserve (*M. humberti*).

The conservation status of *F. ambohitra*, *F. manonae* sp. nov., and one species of *Glabrithelphusa* Meyer *et al.*, 2014 has not yet been assessed because these taxa were described since the IUCN global conservation assessment was carried out (Cumberlidge *et al.* 2009). The specimens of *M. humberti* (VU) reported here from near the Baie de Sakalava and from the Orangea Reserve are new locality records for this species, and the specimens from the Montagne des Français Reserve confirm its continued presence after more than 110 years. These new data may well influence the current conservation status of

Table 2. Summary of the freshwater crabs found in Madagascar, with their conservation status assessed using the IUCN Red List protocols (based on data from Cumberlidge *et al.* 2009). Non-threatened categories: LC = Least Concern, NT = Near Threatened. Threatened categories: VU = Vulnerable, EN = Endangered, CR = Critically Endangered. Other categories: DD = Data Deficient. * = not assessed.

Species	LC	NT	VU	EN	CR	DD
<i>Boreathelphusa uglowi</i>			1			
<i>Foza raimundi</i>	1					
<i>Foza goudoti</i>	1					
<i>Foza ambohitra</i> *						
<i>Foza manonae</i> sp. nov. *						
<i>Glabrithelphusa angene</i> *						
<i>Hydrothelphusa agilis</i>	1					
<i>Hydrothelphusa madagascariensis</i>	1					
<i>Hydrothelphusa bombetokensis</i>	1					
<i>Hydrothelphusa vencesi</i>	1					
<i>Madagapotamon humberti</i>			1			
<i>Malagasya antongilensis</i>	1					
<i>Malagasya goodmani</i>						1
<i>Marojejy longimerus</i>						1
<i>Skelosophusa gollhardi</i>						1
<i>Skelosophusa eumeces</i>						1
<i>Skelosophusa proluxa</i>						1
Species per Red List category	7	0	2	0	0	5

M. humberti (VU, Cumberlidge 2008a). The presence of *F. ambohitra* in the Ankarana Special Reserve is a new locality record for this species (Cumberlidge & Meyer 2009), and will be useful when the conservation status of this species is eventually assessed.

Acknowledgements

We thank Dr Frank Glaw and his colleagues for collecting some of the specimens included here that were passed on to the second author (SK) for further study. The first author (NC) prepared the photographs, the second author (SK) prepared the maps, and the fourth author (JCK) prepared Figs 1 and 2. We also thank Dr Steven M. Goodman of the Field Museum, Chicago, for some of the specimens included here, and we are grateful to Marty Prydzia, Joachim Gerber, and Dr Janet Voight of the Field Museum for kindly lending some of the specimens used in this study. SK was supported by a Fellowship for Young International Scientists of the Chinese Academy of Sciences (no. 2013Y1SA0006).

References

- Bahir M.M., Ng P.K.L., Crandall K. & Pethiyagoda R. 2005. A conservation assessment of the freshwater crabs of Sri Lanka. *The Raffles Bulletin of Zoology*, Suppl. 12: 121–126.
- Bott R. 1960. Crustacea (Decapoda): Potamonidae. *In*: Hanstrom B., Brinck P. & Ruderbeck G. (eds) *South African Animal Life: Results of the Lund University Expedition in 1950–1951*, vol. 7: 13–18. Almqvist & Wiksells, Uppsala.

- Bott R. 1965. Die Süßwasserkrabben von Madagaskar. *Bulletin du Muséum national d'Histoire naturelle* 37 (2): 335–350.
- Cumberlidge N. 1999. The Freshwater Crabs of West Africa, Family Potamonautidae. *Faune et Flore Tropicales* 35, IRD, Paris.
- Cumberlidge N. 2008a. *Madagapotamon humberti*. In: IUCN 2013. *IUCN Red List of Threatened Species*. Version 2013.2. www.iucnredlist.org. Downloaded 13 May 2014.
- Cumberlidge N. 2008b. *Boreas uglowi*. In: IUCN 2013. *IUCN Red List of Threatened Species*. Version 2013.2. www.iucnredlist.org. Downloaded 13 May 2014.
- Cumberlidge N. 2014. An overview of the Afrotropical freshwater crab fauna: Diversity, biogeography, and conservation (Brachyura, Potamoidea, Potamonautidae and Potamidae). In: Yeo D., Cumberlidge N. & Klaus S. (eds.) *Crustaceana Monographs: Advances in Freshwater Decapod Systematics and Biology*: 71–99. Koninklijke Brill, The Netherlands. http://dx.doi.org/10.1163/9789004207615_006
- Cumberlidge N. & Meyer K.S. 2009. A new species of *Foza* Reed & Cumberlidge, 2006, from northern Madagascar (Decapoda, Brachyura, Potamoidea, Potamonautidae), with a redescription of *F. goudoti* (H. Milne Edwards, 1853) comb. n., and comments on *Skelosophusa prolixa* Ng & Takeda, 1994. *ZooKeys* 18: 77–89. <http://dx.doi.org/10.3897/zookeys.18.102>
- Cumberlidge N. & Sternberg R. 2002. The freshwater crabs of Madagascar (Crustacea, Decapoda, Potamoidea). *Zoosystema* 24: 41–79.
- Cumberlidge N., Boyko C.B. & Harvey A.W. 2002. A new genus and species of freshwater crab (Decapoda, Crustacea, Potamoidea) from northern Madagascar, and a second new species associated with *Pandanus leafaxils*. *Journal of Natural History* 36: 65–77. <http://dx.doi.org/10.1080/00222930010003800>
- Cumberlidge N., Reed S.K. & Boyko C.B. 2004. Distribution patterns of the Malagasy freshwater crabs (Crustacea: Decapoda: Brachyura). *Journal of Natural History* 38: 1133–1157. <http://dx.doi.org/10.1080/0022293031000068419>
- Cumberlidge N., Fenolio D.B., Walvoord M.E. & Stout J. 2005. Tree-climbing crabs (Potamonautidae and Sesarmidae) from phytotelmic microhabitats in rainforest canopy in Madagascar. *Journal of Crustacean Biology* 25: 302–308. <http://dx.doi.org/10.1651/C-2532>
- Cumberlidge N., Marijnissen S.A.E. & Thompson J. 2007. *Hydrothelphusa vencesi*, a new species of freshwater crab (Brachyura: Potamoidea: Potamonautidae) from southeastern Madagascar. *Zootaxa* 1524: 61–68.
- Cumberlidge N., Ng P.K.L., Yeo D.C.J., Magalhaes C., Campos M.R., Alvarez F., Naruse T., Daniels S.R., Esser L.J., Attipoe F.Y.K., Clotilde-Ba F.-L., Darwall W.R.T., McIvor A., Ram M. & Collen B. 2009. Freshwater crabs and the biodiversity crisis: importance, threats, status, and conservation challenges. *Biological Conservation* 142: 1665–1673. <http://dx.doi.org/10.1016/j.biocon.2009.02.038>
- Meyer K.S., Cumberlidge N. & Koppin J.C. 2014. A new genus and species of freshwater crab from Madagascar (Decapoda, Brachyura, Potamoidea, Potamonautidae). *Zootaxa* 3884: 65–72. <http://dx.doi.org/10.11646/zootaxa.3884.1.5>
- Ng P.K.L. & Takeda M. 1994. *Skelosophusa* (Crustacea, Decapoda, Brachyura), a new genus of potamonautid freshwater crab from Madagascar, with descriptions of two new species. *Bulletin of the National Science Museum, Series A (Zoology)* 20: 161–172.
- Ng P.K.L., Guinot D. & Davie P. 2008. Systema Brachyurorum: Part I. An annotated checklist of extant brachyuran crabs of the world. *The Raffles Bulletin of Zoology, Suppl.* 17: 1–286.

Reed S.K. & Cumberlidge N. 2006. *Foza raimundi*, a new genus and species of potamonautid freshwater crab (Crustacea: Decapoda: Potamoidea) from northern Madagascar. *Proceedings of the Biological Society of Washington* 119: 58–66. [http://dx.doi.org/10.2988/0006-324X\(2006\)119%5B58:FRANGA%5D2.0.CO;2](http://dx.doi.org/10.2988/0006-324X(2006)119%5B58:FRANGA%5D2.0.CO;2)

Sternberg R. & Cumberlidge N. 2001. Notes on the position of the true freshwater crabs within the brachyrhynchan Eubrachyura (Crustacea: Decapoda: Brachyura). *Hydrobiologia* 449: 21–39. <http://dx.doi.org/10.1023/A:1017560113027>

Vuillemin S. 1970. Observations écologiques et biologiques sur *Madagapotamon humberti* Bott, 1965 (Crustacé, Décapode, Potamonidé) du massif de l'Ankarana (Madagascar). *Annales de l'Université de Madagascar* 7: 245–266.

Manuscript received: 26 August 2014

Manuscript accepted: 4 November 2014

Published on: 15 January 2015

Topic editor: Rudy Jocqué

Desk editor: Danny Eibye-Jacobsen

Printed versions of all papers are also deposited in the libraries of the institutes that are members of the *EJT* consortium: Muséum National d'Histoire Naturelle, Paris, France; National Botanic Garden of Belgium, Meise, Belgium; Royal Museum for Central Africa, Tervuren, Belgium; National History Museum, London, United Kingdom; Royal Belgian Institute of Natural Sciences, Brussels, Belgium; Natural History Museum of Denmark, Copenhagen, Denmark.